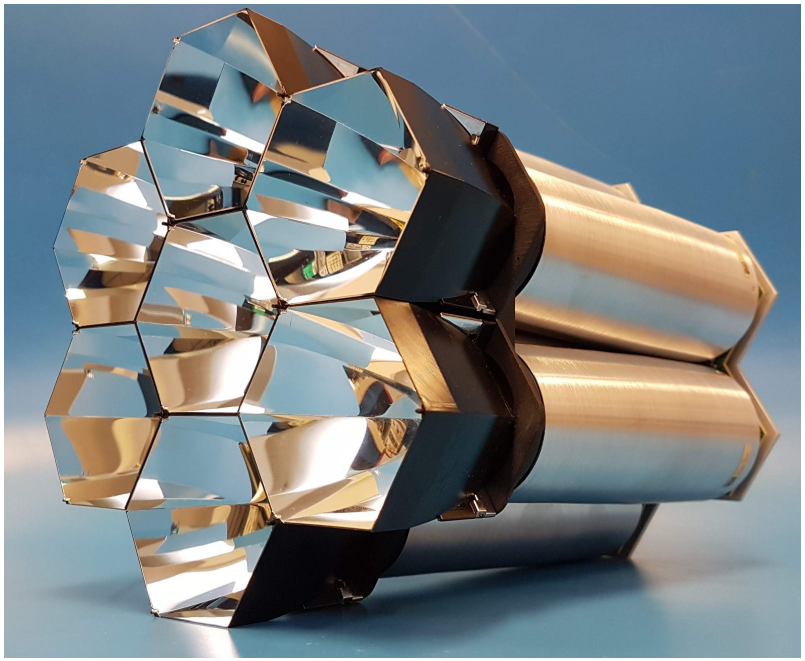
Status of FPM activities



Ch. Jarnot, P. Jean, G. Jobert, J. Knödlseder, Ch. Marty,
J.F. Olive, Th. Ravel, V. Touzard, A. Tsiahina, V. Waegebaert
O. Ferreira, A. Sanuy, D. Gascon

P. Jean – NectarCAM meeting – 11-13 October 2021

Status of the Focal Plane Module for the NectarCAM QM

- History of the production, tests and delivery of FPMs

> Production of 27 FPMs/week from November 2019 to February 2020.

> Performance tests at IRAP completed in mid May 2020.

> Lot of issues detected (e.g. bad PMT/DU/channel associations,...).

> Verification and modification campaign & firmware update in January 2021

> Delivery of FPM to IRFU from January 2021 to July 2021

> First measurements at IRFU in August-September 2021

> IRFU sent back some FPMs with abnormal PMTs to IRAP for further analyses in October and December 2021

Status of the Focal Plane Module for the NectarCAM QM

• Measurements at IRFU

- Observation of abnormal pixels during the first tests.

> too high noise with and without HV,

> too low gain (HG or/and LG).

See the “20/09/2021” section in the Data Analysis Wiki pages

- In April-May 2022 long duration runs: Pedestal & Flat Field.

Unstable pixels with random variation of:

> gain (HG or LG)

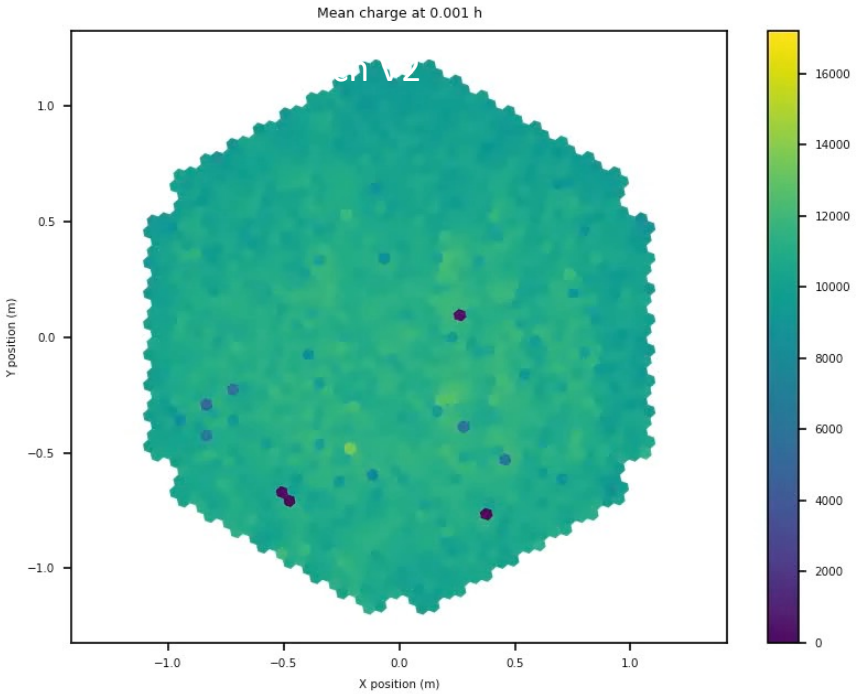
> pedestal fluctuations

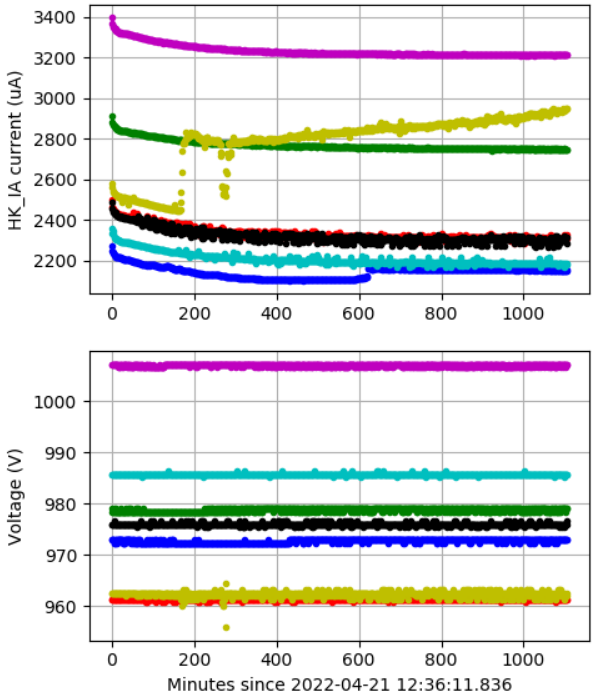
> slow control (currents, HVs,…)

- Statistics:

Detection of anomalies in ~ 7% of pixels in 4 runs of ~ 15 hours.

See the "22/06/2022” section in the Data Analysis Wiki pages





Status of the Focal Plane Module for the NectarCAM QM

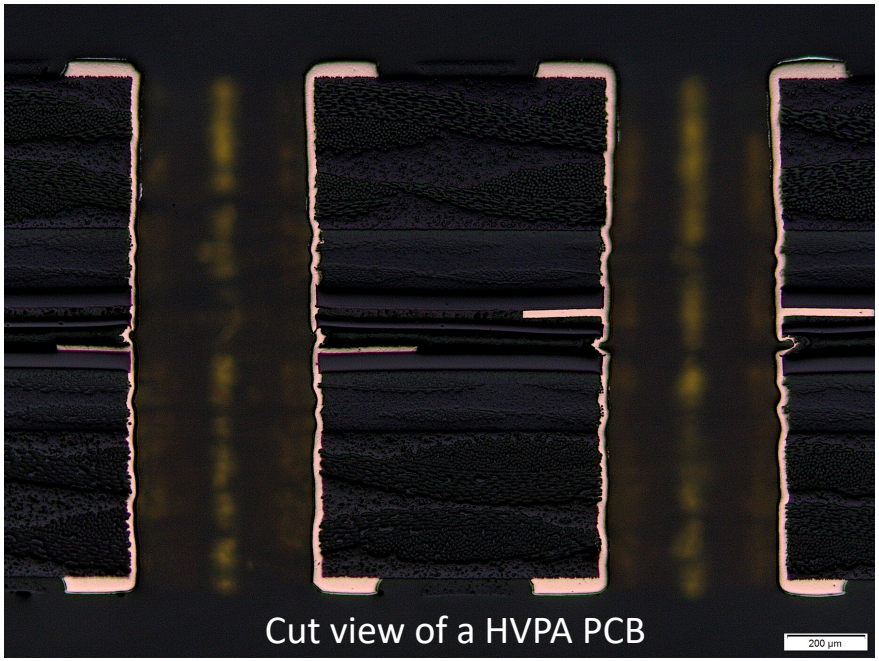
• Analyses at IRAP

- Defaults of impedances of HVPA PCBs vias:

  > bad or variability in the transmission of pulses.

  > variation of voltages that control the board (e.g. HV)

  => noise and gain variations



Cut view of a HVPA PCB

- Expertise of HVPA and IB boards

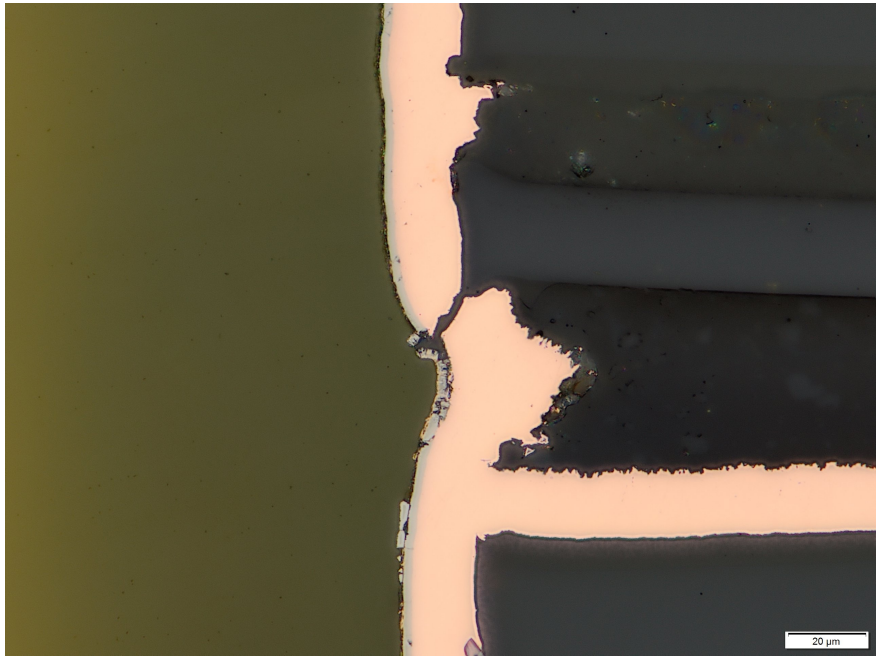
  > Made by Elemca and RME

  > Too thin conductive layers

  > Discontinuity in layers of Copper

  > Too many anomalies detected in vias of HVPA board

The PCBs of the HVPA do not fulfill the IPC610 specification!



Status of the Focal Plane Module for the NectarCAM QM

• IRAP sent a non conformity notification to Microtec

- Meeting at Microtec with IRAP and some members of the NectarCAM collaboration, the July 6th, 2022.

- Microtec recognized the bad manufacturing of HVPA board.

- The subcontractor (Apertech) that produced PCBs did not respect the IPC610 specifications.

- Microtec requested compensation from its subcontractor.

- Microtec proposed to make an other production of FPM (“QM bis”) paid with its insurance.

- The process between insurance experts of Microtec and Apertech is in progress.

Preparation of the mass production

- Procurement of components

  - PMTs: ordered for 4 NectarCAMs.

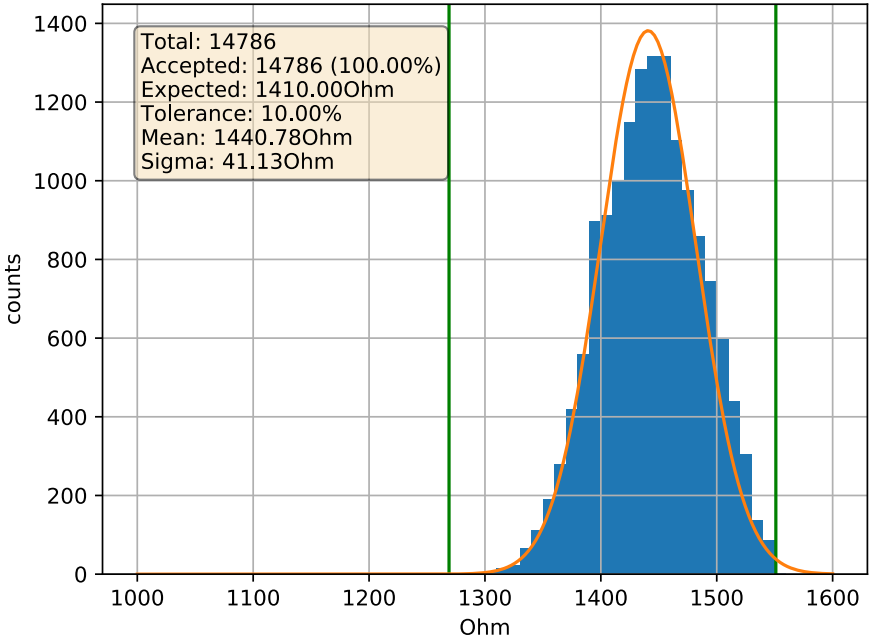
  - PACTA: 21000 ASICs received and validated by Andreu Sanuy at UB.

  - Microcontrollers: ordered for 8 cameras.

  - Electronics components: ordering for 8 cameras would be sent before 2023.

PMTs stored at IRAP

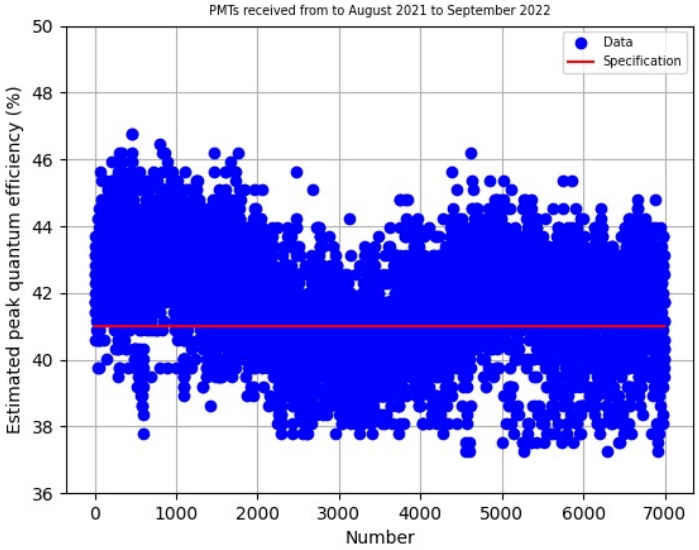
HG transimpedance of PACTA produced in 2021

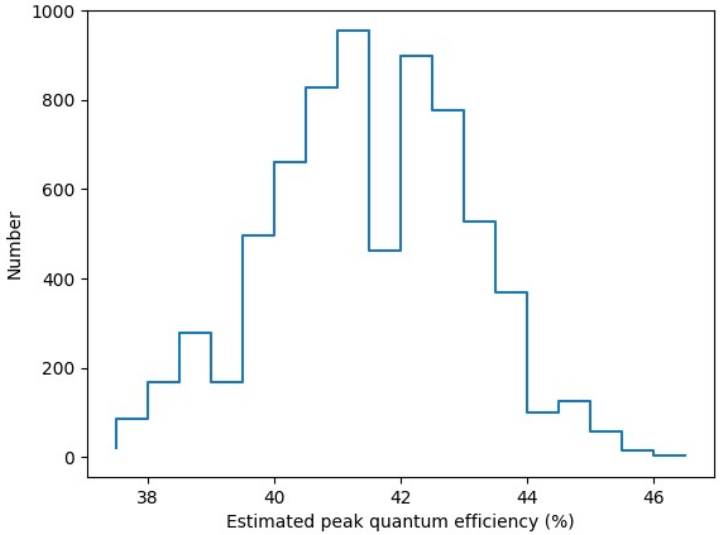


Preparation of the mass production

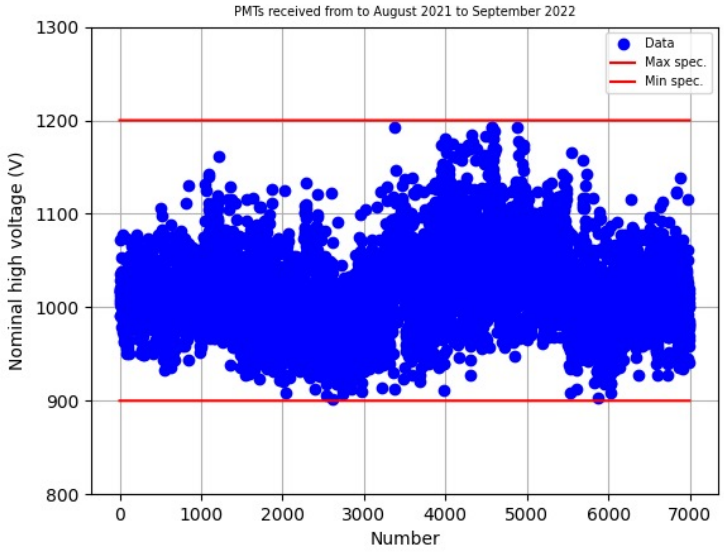
- Performances of the 7000 PMTs received so far (data from Hamamatsu)

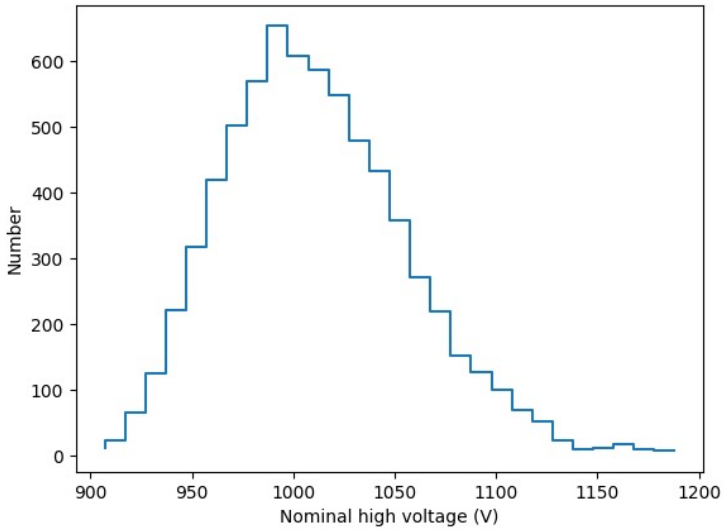
> Estimated peak quantum efficiency





> Nominal high voltage





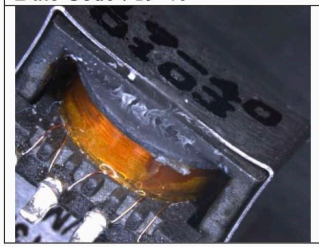
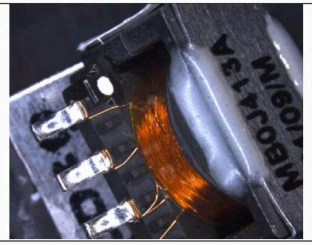
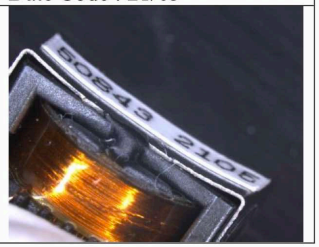
Preparation of the mass production

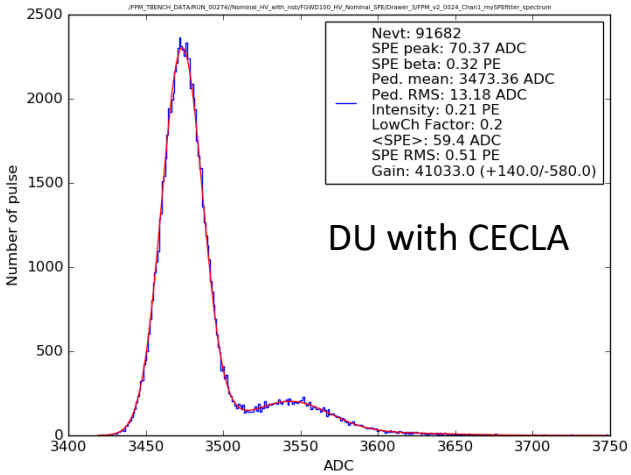
- Test of alternative to CECLA transformers

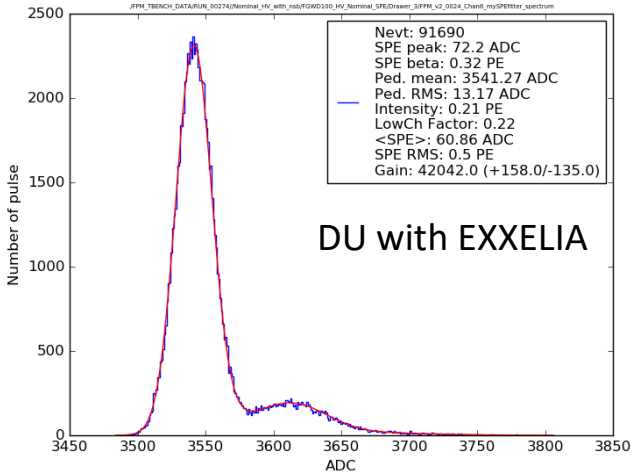
  - Alternative manufacturers: EXXELIA and SAMCON

  - Transformers tested and soldered on a HVPA board of a DU.

  - Performances measured with the FPM Test bench => validated

CECLA réf. 84423A N°103 Date Code : 19-40	**EXXELIA** ref. MBOJ413A Date code : 21/09	**SAMCON** réf. 50843 Date Code : 21/05
		





- Next steps: production of prototypes

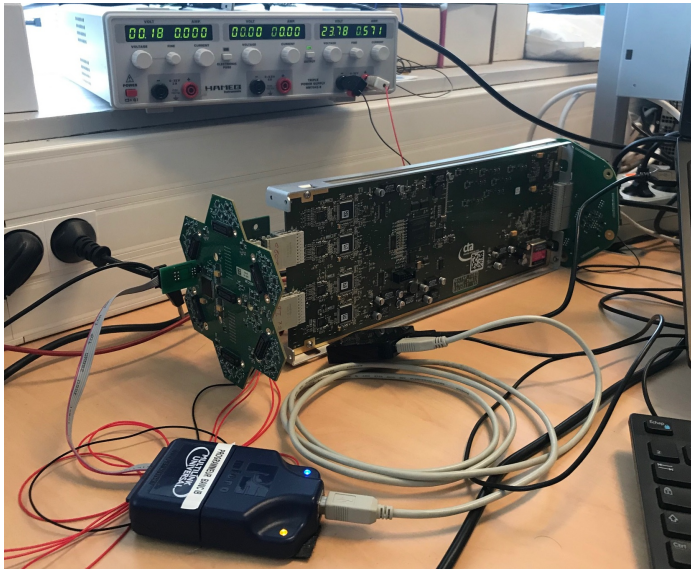
  - Electronic boards: HVPA v6 and IB v6

    > Kapton replaced by ThinFlex; HVPA board has to be slightly modified.

    > Re-routing and production of prototypes.

  - FPMs prototypes to validate the industrial production process.

Preparation of the mass production



• Optimization of the Interface Board control (v3.2)

- Remote programming of the microcontroller

> Development of a bootloader code in the flash memory of the microcontroller.

> Tests and validation performed at IRAP.

> Modifications of the FEB software (Vincent Voisin, LPNHE)

> Validation with one FPM on the NectarCAM in April 2022 (Patrick Sizun, IRFU).

- Update and improvement of the microcontroller firmware

> Firmware version, IB and FPM id numbers written in the microcontroller memory.

> New control commands (e.g. switch value for the current trips, reset of the software…)

- Further developments/improvements expected: work in progress, Meeting at IRAP end of October.

Preparation of the mass production

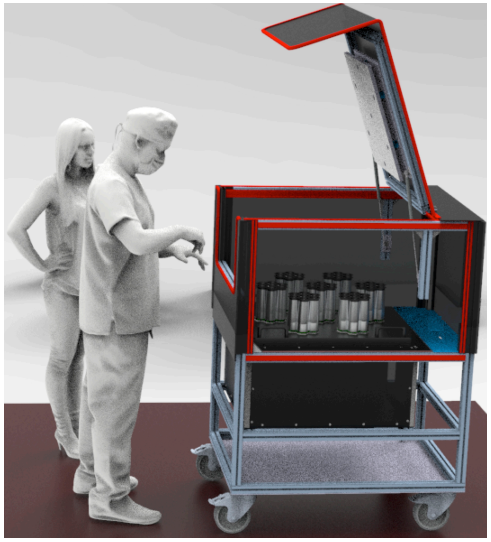
- FPM test bench for the industry.

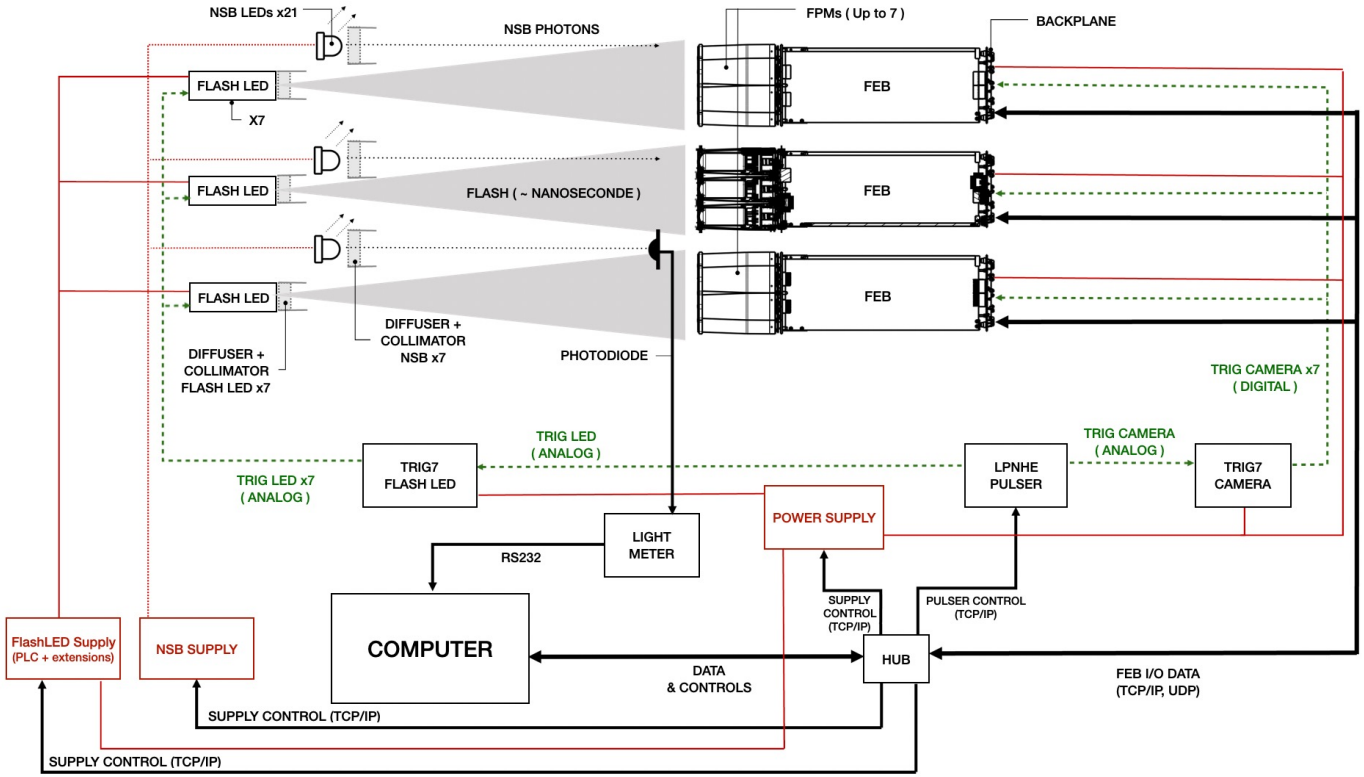
  > Aims: functional & main performance tests (see Adellain's talk)

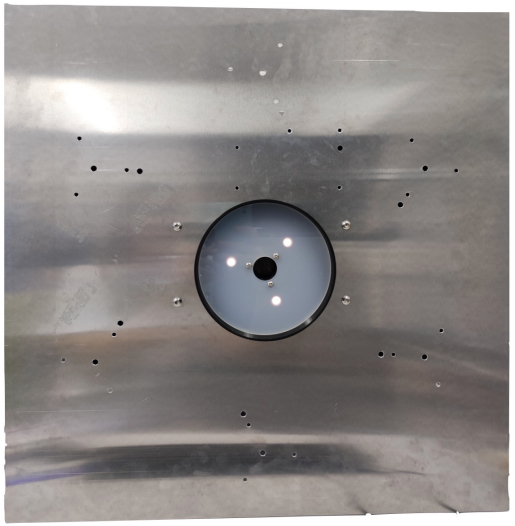
  > Mechanical design completed.

  > Mechanical assembly in progress

  > Software to control of the FPM test bench: in progress



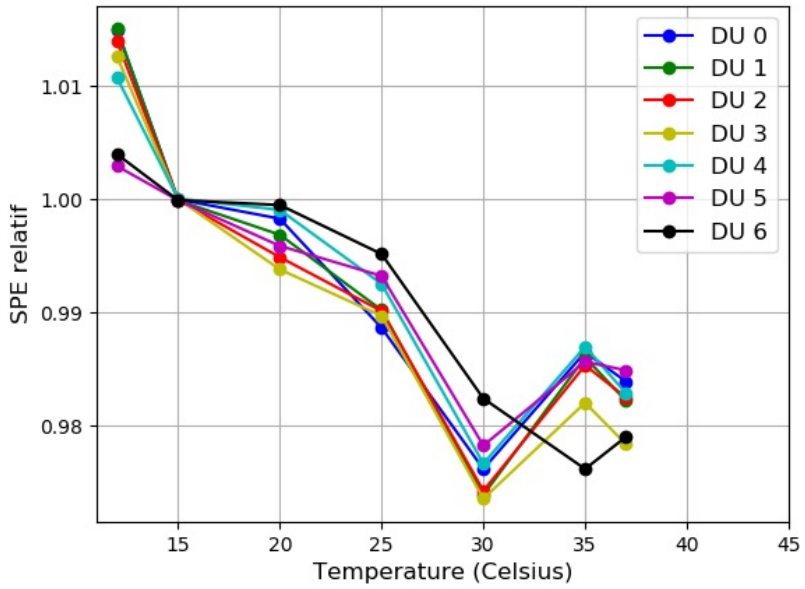




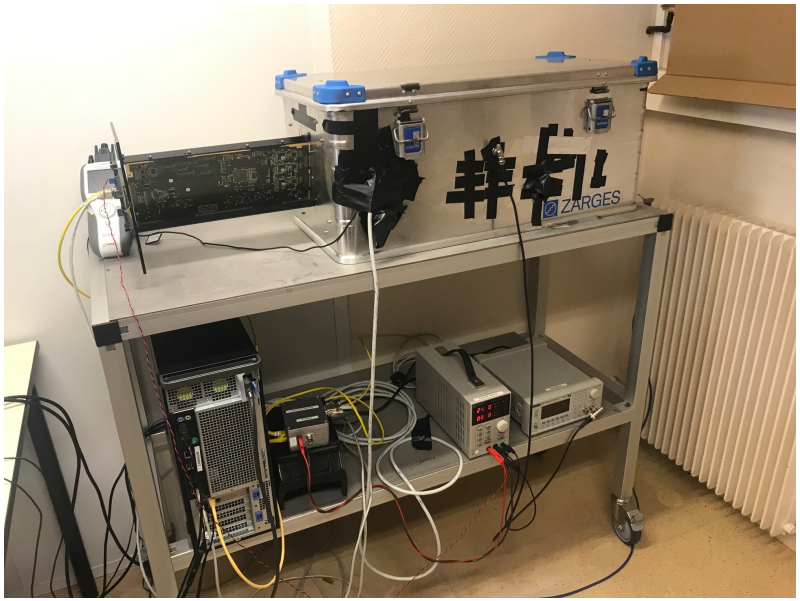
Mechanical support of the light source system

Other activities

- Variation of performances with temperature (internship in 2022)
  - Aims: Re-do measurements performed in 2018 but with a new FPM
  - No significant variation of pedestal fluctuations with temperature
  - Gain variation with temperature of about -0.4%/°C



- Stress tests
  - Aims: detect any default in a large number of On/Off cycles
  - Made with the FPM 42 (from Adlershof tests) and a FEB v5.
  - Cycle with On/HV on/pulses & Slow Control acquisitions/HV off/Off
  - 7300 cycles performed – equivalent to ~30 years of operation.
  - No issue detected.



Other activities

- Thermal tests

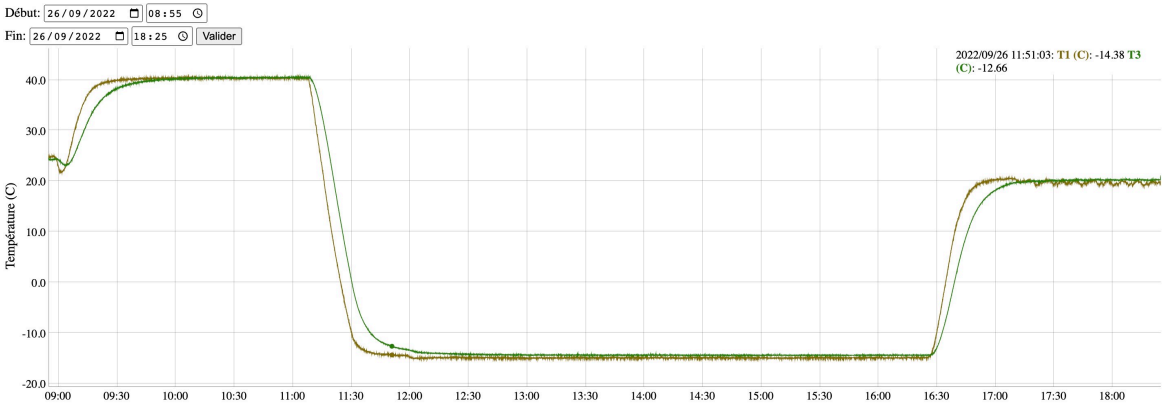
  - Aims: Check whether a FPM of the QM survives negative temperatures

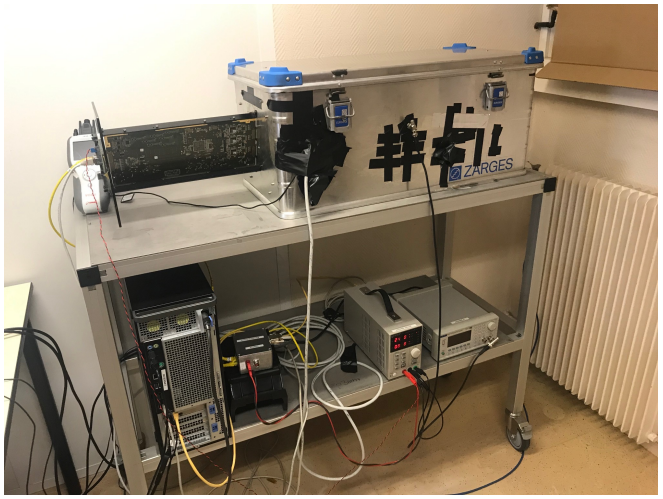
  - Made with the FPM 292.

  - Performances (pedestal, pulse) measured before and after the stay.

  - Few hours at temperature of -10°C, -15°C and -20 °C.

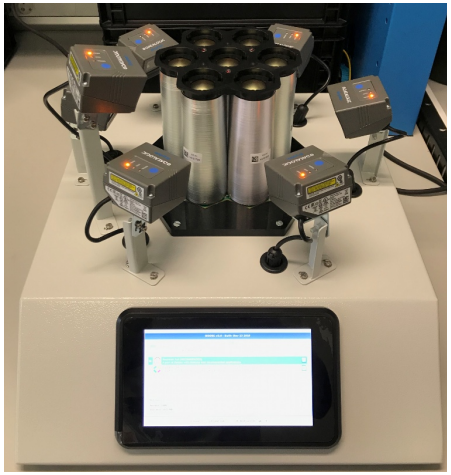
  - No issue detected so far.





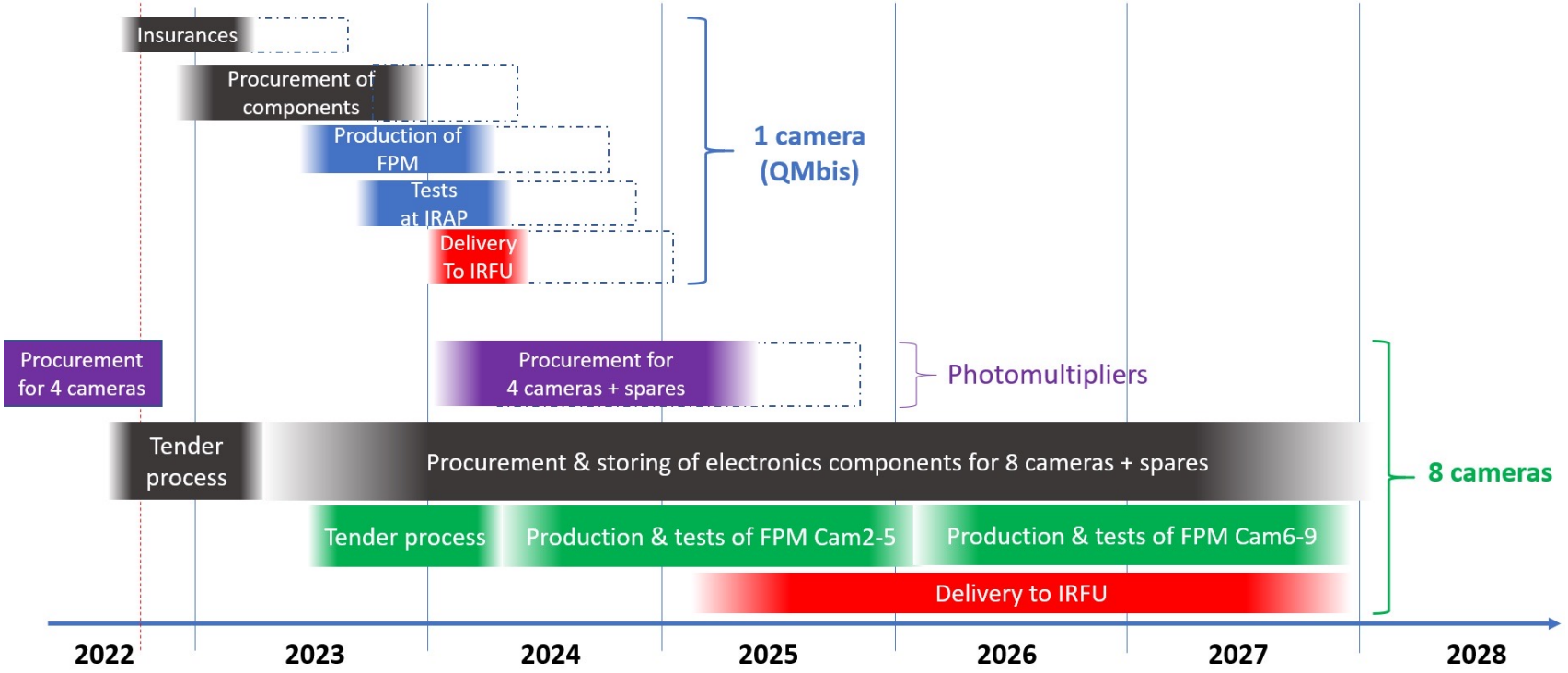
Draft schedule

Traceability tools



- Next tasks to complete
  - Few minor RIX to close.
  - FPM test bench for industry (mechanics, integration, calibration).
  - HVPA, IB and DU test benches (maintenance).
  - Traceability tools
  - Validation of prototypes (v6 electronics boards and FPMs)

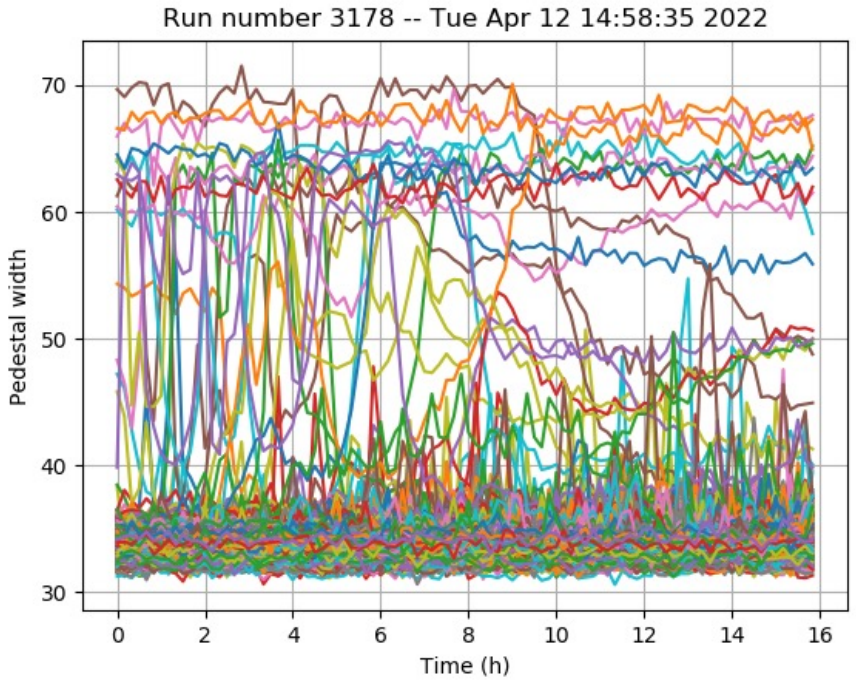
- Production planning (managed by Christophe Marty)
  - Lot of uncertainties in the production of FPMs for the QMbis.



Thank you

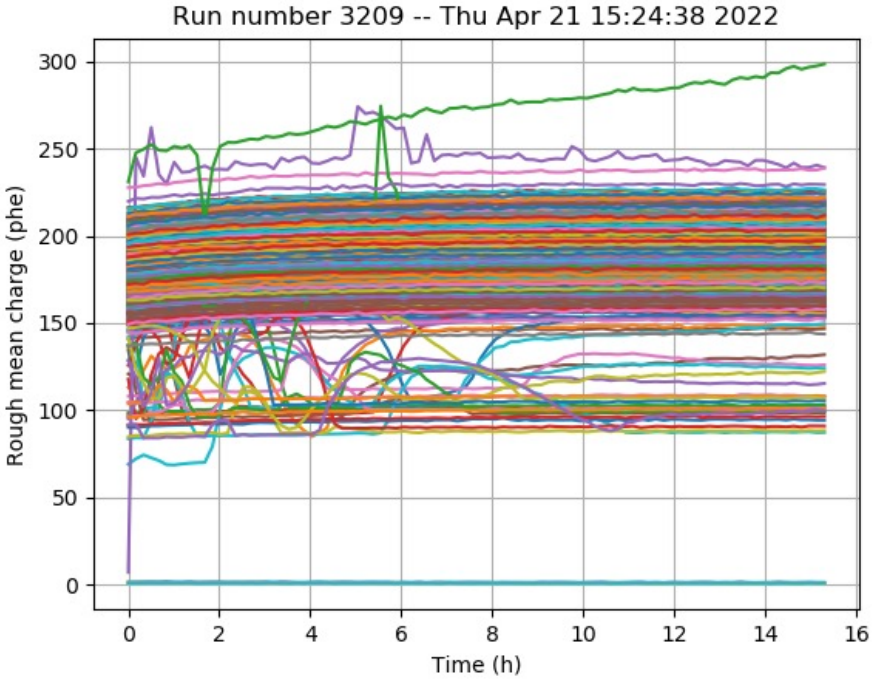
Long duration runs

Pedestal fluctuations
(Δt = 60 ns)



Low gain

Mean charge



High gain